Final Report

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

ENERGY EFFICIENT RETROFIT OF A MUNICIPAL BUILDINGS CODIAC TRANSIT BUS GARAGE MONCTON, N. B.

CREDA PROJECT: 2061

REPORT BY: ENERPLAN CONSULTANTS LTD.

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

Conservation & Renewable
Energy Division
Energy Secretariat
P.O. Box 6000
Fredericton, N.B.
E3B 5H1
(506) 453-3897

Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

Division des économies d'énergie
et des énergies renouvelables
Secrétariat à l'énergie
C.P. 6000
Fredericton, N.-B.
E3B 5H1
(506) 453-3897

D I S C L A I M E R

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D E N I D E R E S P O N S A B I L I T E

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1.0 EXECUTIVE SUMMARY

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Codiac Transit Bus Garage, approximately 23,500 square feet in area, was retrofitted with a new roof and heating system. The new roof was installed on the indoor parking section of the garage only. Sloped insulation was used with a single ply roofing membrane to overcome past problems with leaks due to pooling of rainwater. A gas fired radiant tube heating system was used in the indoor garage and service garage to replace suspended hot air furnaces. Three high efficency propane fired boilers and a gas fired domestic hot water heater were used to replace the oil fired units used previously for office and shop space heating and domestic hot water heating.

The new heating system has proven to be a satisfactory and effective alternative to the conventional oil fired systems common in warehouses and garages. Mechanics find their work environment quite comfortable.

The new roof installation has yet to prove itself by enduring the test of time. One of the key advantages of the single ply roofing membrane is its durability and low maintenance costs.

Post-retrofit energy reduction for October to December 1984, inclusive, adjusted for degree days, was 22.4% for 1984 versus 1982, and 19.8% for 1984 versus 1983.

However, due to the high cost of propane in Moncton, energy cost actually increased, by 3.5% over 1982, and 6.9% over 1983.

Therefore, the heating aspect of this project is very attractive when natural gas or propane costs are competitive with oil.

1.0 RESUME

Le garage d'autobus de transit Codiac, d'une superficie d'environ 23 500 pieds carrés, a été l'objet de rénovations consistant en un nouveau toit et un système de chauffage. Le toit a été installé uniquement dans la section du garage réservée au stationnement intérieur. On a fixé l'isolation de façon inclinée en la retenant à l'aide d'une membrane de toit simple afin d'éviter d'anciens problèmes causés par l'accumulation de l'eau de pluie. Un système de chauffage rayonnant fonctionnant au gaz propane remplace maintenant les calorifères à air chaud suspendus qui réchauffaient le garage intérieur et l'atelier de réparation. quant à la partie réservée aux bureaux, les appareils au mazout servant jusque-là au chauffage des locaux et de l'eau domestique y ont été remplacés par des brûleurs au gaz propane à haute efficacité énergétique et un chauffe-eau alimenté au gaz.

Le nouveau système de chauffage s'est révélé satisfaisant et efficace, et il a bien remplacé les appareils conventionnels alimentés au mazout qu'on retrouve normalement dans les entrepôts et les garages. Les mécaniciens trouvent que leur milieu de travail est plutôt confortable.

quant au nouveau toit, il lui reste encore à subir le test du temps. L'un des principaux avantages de la membrane de toit simple est sa durabilité et son faible coût d'entretien.

Une réduction d'énergie de 22.4%, ajusté pour degrés-jours, fût réalisée durant la période d'octobre à décembre 1984 comparé à la même période en 1982, et de 19.8% comparé à celle de 1983.

Mais, dû aux coûts élevés du propane dans la région de Moncton, les coûts d'énergie ont augmenté de 3.5% comparé à 1982 et de 6.9% comparé à 1983.

Alors, on peut conclure que ce projet a démontré des économies d'énergie substantielles et serait très attrayant si le coût du propane ou du gaz naturel devient compétitif avec le prix de l'huile à chauffage.

2.0 INTRODUCTION

2.0 INTRODUCTION

During the summer of 1982 an energy study was completed on the Codiac Transit Bus Garage for the City of Moncton by Enerplan Consultants Ltd. As a result of this study it was decided that the problem of heat loss due to a roof in poor condition and a heating system that was inefficient should be addressed.

Enerplan Consultants prepared and submitted a proposal for an energy demonstration project on the bus garage to the Energy Secretariat of New Brunswick. The primary objective was to demonstrate reduction in energy consumption by feasible methods of retrofit. A secondary objective was to demonstrate the installation and performance of single ply roofing membrane as an alternative to the conventional tar and gravel roof. The proposal was accepted for funding under the Conservation and Renewable Energy Development Agreement in the fall of 1983.

The retrofit technologies used in this project are considered to be applicable to other garages and warehouses with flat roofs and high ceilings.

The oil bills were collected and analysed before the energy retrofit. After the retrofit the propane consumption was monitored for the few months of use before the writing of this report. A comparison based on centigrade degree days was made and a projected annual savings was calculated.

3.0 DESCRIPTION

3.0 DESCRIPTION

3.1 Roof

The existing roof was 2 inches of insulation on a metal deck with a four ply roofing membrane and tar and gravel covering. Due to settling of the building since construction, the roof was not draining properly and water leakage was occurring at spots where pools of water formed.

The new roof installation involved removal of old tar and gravel and wet insulation* and replacement by new insulation with an extra 4 inch thickness (on average) and a single ply roofing membrane. (EPDM) The new insulation was to be installed so that the roof would slope from the roof edge to the drain with a height differential of 2 inches. Ballast of 10 lbs/sq.ft. was to be loosely laid over the entire surface.

*Wet insulation was located using a thermographic scan (Appendix C).

3.2 Heating and Domestic Hot Water

The existing heating system was by suspended hot air furnaces in the garage areas and by hot water baseboard radiation in the offices. Domestic hot water and heating was all oil fired. Thermostats were provided for each furnace and one thermostat controlled office radiation.

The new heating system uses gas fired radiant heating tubes suspended from the ceiling for the main bus areas. Unit heaters are used in the paint shop and areas where combustible fumes exist. Three gas fired boilers provide hot water to the unit heaters and office radiation. Controls are provided to allow automatic night setback of temperature for unoccupied periods.

Plans and schematics of the retrofit can be found in Appendix "A".

4.0 MONITORING

4.0 MONITORING

4.1 General

The energy consumption of the Codiac Transit Building was monitored using the invoices of fuel suppliers before and after the retrofit.

The roof installation was observed and areas of wet insulation were noted for comparison with the thermography study.

At the time of this writing final adjustments were still being made to controls, but all equipment is functioning satisfactorily.

4.2 Roof

The roof thermography study outlined the wetspots with less than 10 per cent error which is considered very good for the type of thermography done. Repair was done by cutting out wet insulation in an ever widening area until dry insulation was exposed. Then new dry insulation was installed to replace wet material and 4 inches of additional insulation was installed with an intended slope of 2 inches from roof edge to drain. Single ply (EPDM) roofing membrane was applied over the insulation and covered with ballast.

4.3 Heating System

The heating system was installed without any major problems. Clearance above the buses was a concern but there doesn't appear to be any problem.

An ongoing problem in the building has been the thermostat setpoints being too high. As of this writing tamperproof covers are to be installed and hopefully design setpoints will be adhered to.

4.4 Performance

A comparison was done based on fuel usage from October to December 1984, inclusive, using centrigade degree day data. The equivalent kilowatt hour per degree day figures show a 22.4% reduction in energy use comparing 1984 propane with 1982 oil and a 19.8% reduction comparing 1984 propane with 1983 oil.

The dollar cost comparison done with current city costs for oil and propane ($0.308 oil, $0.2638 propane) show a cost increase of 3.5 % for 1982 versus 1984 and 6.9% for 1983 versus 1984.

4.4 Performance (Cont'd)

Note that the city has a 21.4% discount on the current price of furnace oil as compared to homeowner's cost. Discount on propane is only about 9%. Prices for oil obviously did not escalate at the same rate as the cost of propane in the case of the city costs; however, future years will probably see quite different price structures.

A greater energy reduction will occur, no doubt, after tamperproof covers are installed on thermostats.

5.0 PROJECT COST ACCOUNTING

5.0 PROJECT COST ACCOUNTING

5.1 Total Project Cost & Funding

The cost breakdown for this project is listed below:

Capital Construction:	
Roof	$ 80,343.36
Heating System	$ 77,849.00
Engineering and Management	$ 15,000.00
Performance Monitoring	$ 6,500.00
Information Transfer	$ 4,000.00
Final Report	$ 2,000.00
PROJECT TOTAL	**$185,692.36**
CREDA Funding	$ 82,000.00
City Funding	$103,692.36

5.2 Cost Benefit Analysis

The price structure for fuel paid by the city results in an operating cost loss of between 3.5 and 7% based on current rates. However, the employees feel much more comfortable than they were with the previous system.

A projected operating budget for one year with propane based on the existing months of operating gives a total consumption of 18,226 litres at a cost of $4,808.00 per year. The table on the following page compares 1982, 1983 and 1984 consumptions for October to December inclusive.

5.0 PROJECT COST ACCOUNTING (Cont'd)

5.2 Cost Benefit Analysis (Cont'd)

Fuel Consumption Analysis
October to December

Year	Fuel Type	Litres	Litres / °C Days	Litres / °C Day	eq. Kwh / °C Day	$ / °C Day
1982	No. 2 Oil	15,367	1,511	10.17	111.5	3.13
1983	No. 2 Oil	14,877	1,513.1	9.83	107.8	3.03
1984	Propane	18,226	1,483.2	12.2	86.5	3.24

1 litre No. 2 Oil = 10.96 Kwh $/litre No. 2 Oil (City) = $0.308/litre

1 litre Propane = 7.09 Kwh $/litre Propane (City) = $0.2638/litre

6.0 INFORMATION TRANSFER

6.0 INFORMATION TRANSFER

6.1 General

The infrared heating system has generated tremendous interest throughout the commercial and industrial building industries in the greater Moncton area. The building manager and Enerplan Consultants have received a number of inquiries about the radiant heating system and several groups of owners have toured the building.

A display featuring the Codiac Transit project was presented at the 'Municipal Energy Conference' in November, 1984 held in Fredericton, NB.

Information about the retrofit was distributed to New Brunswick municipalities.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The installation of a single ply (EPDM) roofing membrane has shown it to be a highly manageable product and easy to install.

The radiant heating system has demonstrated a viable alternative to conventional oil fired heating and it has proven to be very effective in providing a comfortable workplace for mechanics in the garages.

The propane fired boilers have performed reliably and efficiently to date.

7.2 Recommendations

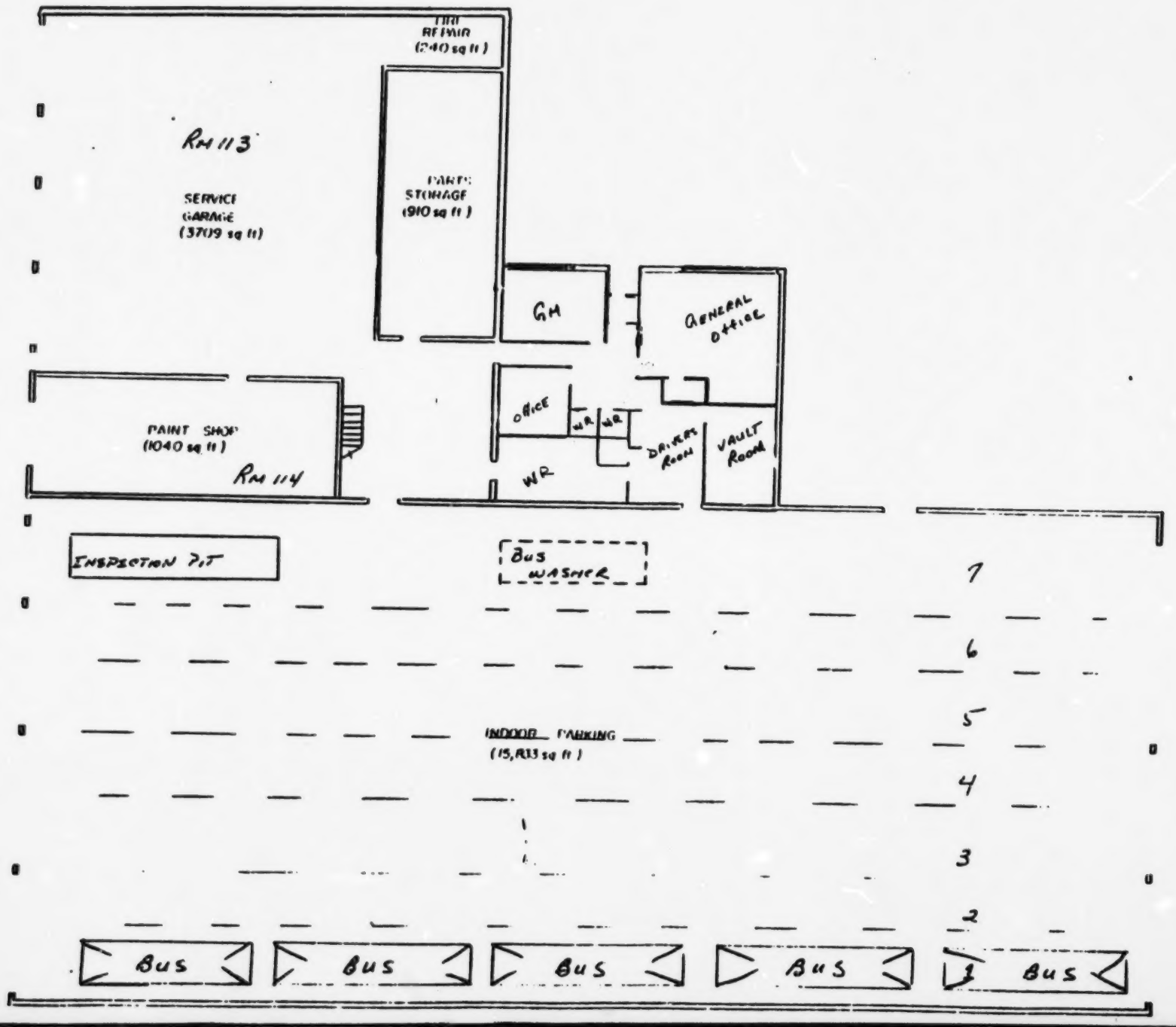
When a new flat roof is required on a building, single ply roofing membrane should be considered as a very durable alternative to tar and gravel.

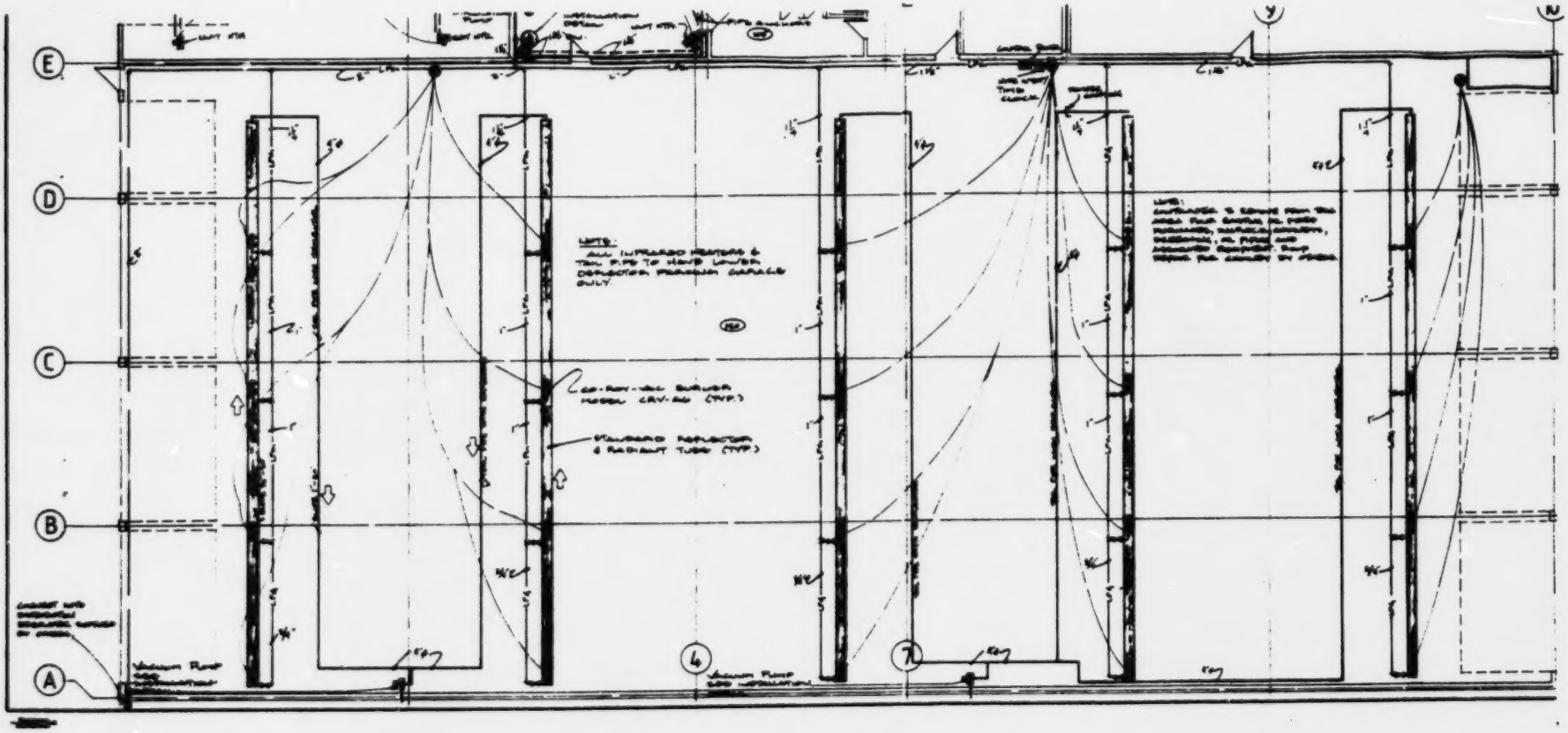
New garages, warehouses or any large building with high infiltration rates should consider radiant heating as a good heat source for providing comfortable working conditions.

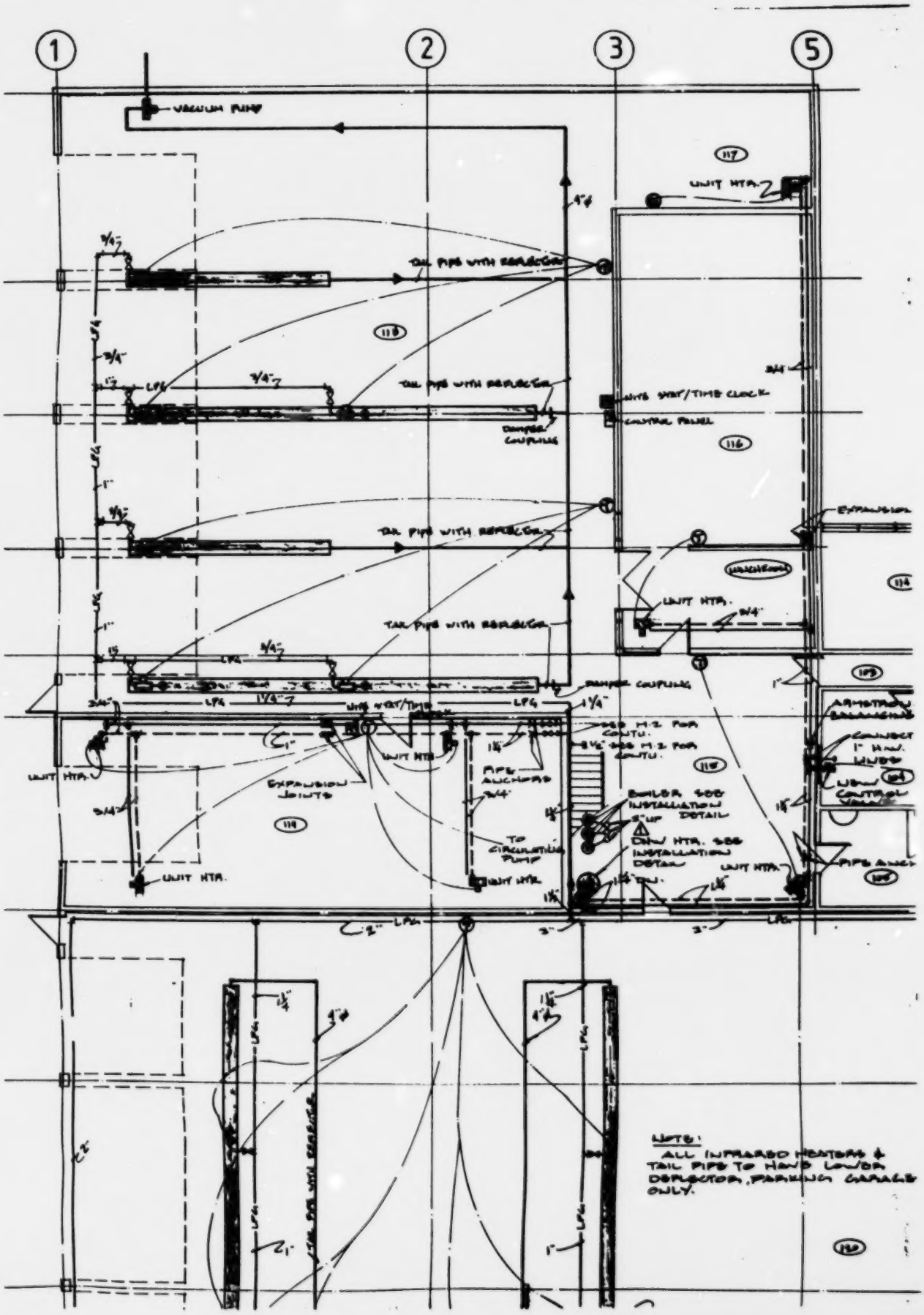
In New Brunswick, where natural gas is expected to become available soon, careful consideration should be given to the operating cost comparison of this fuel type with other available fuel types.

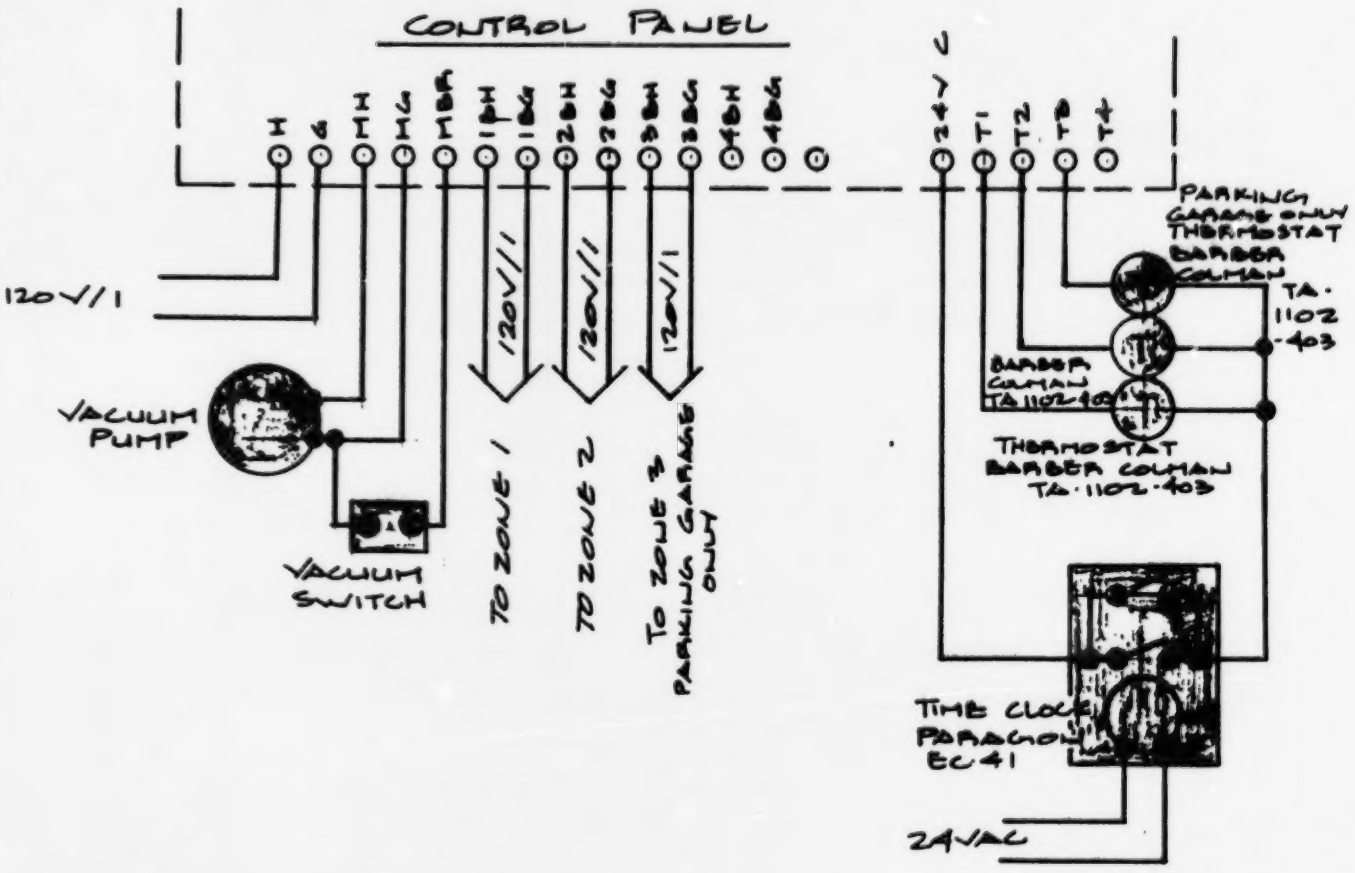
APPENDIX "A"

PLANS AND SCHEMATICS
OF RETROFIT


TIRE REPAIR (240 sq ft)
RM 113
SERVICE GARAGE (3709 sq ft)
PARTS STORAGE (910 sq ft)
GH
GENERAL OFFICE
OFFICE
WR
WR
DRIVERS ROOM
VAULT ROOM
WR
PAINT SHOP (1040 sq ft)
RM 114
INSPECTION PIT
BUS WASHER
7
6
5
INDOOR PARKING (15,833 sq ft)
4
3
2
1
Bus
Bus
Bus
Bus
Bus


E
D
C
B
A
4
7
Y
N

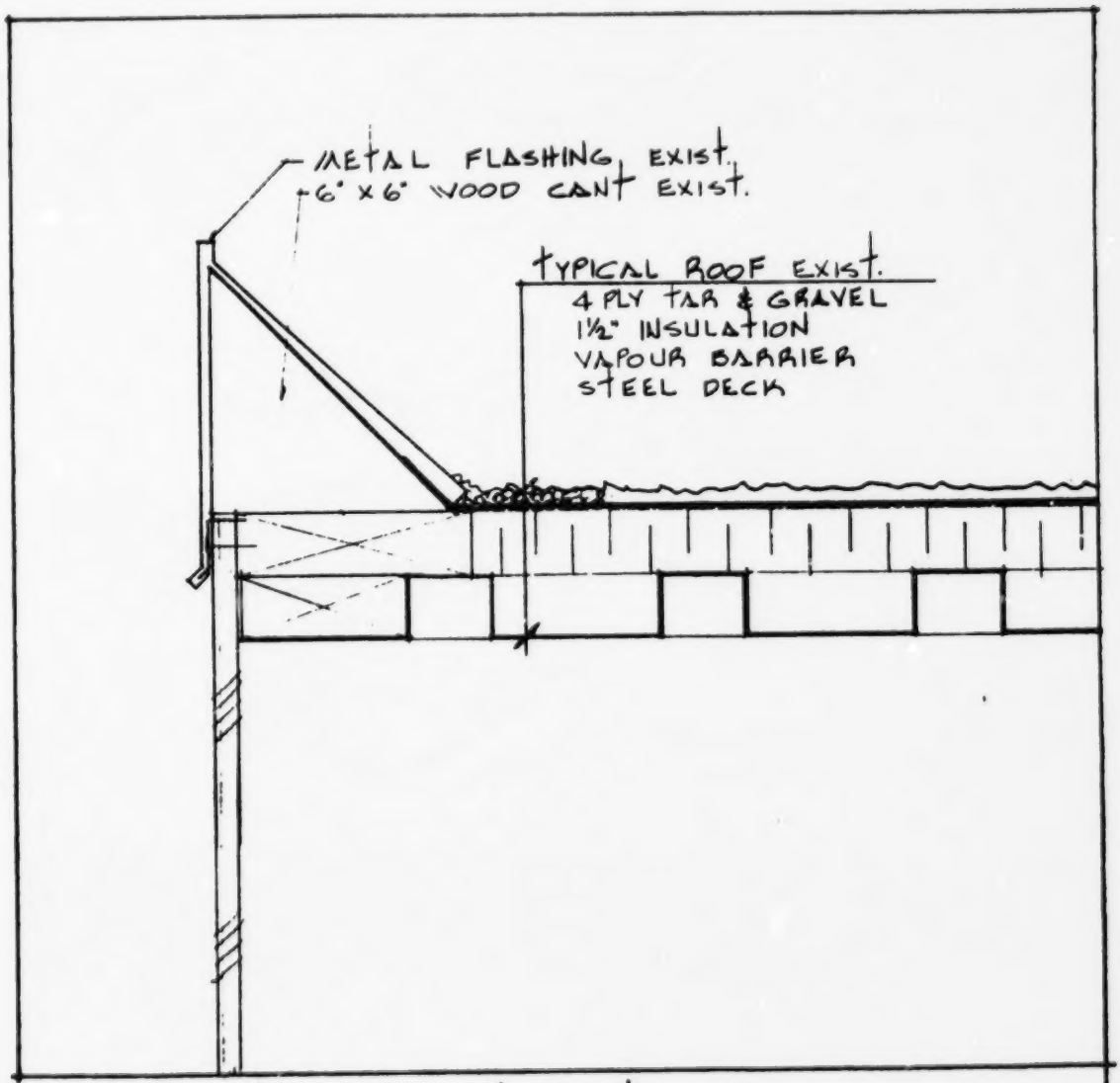

1
2
3
5
VACUUM PUMP
UNIT HTR.
TAIL PIPE WITH REFLECTOR
DAMPER COUPLING
UNIT START/TIME CLOCK
CONTROL PANEL
EXPANSION
UNIT HTR.
TAIL PIPE WITH REFLECTOR
DAMPER COUPLING
UNIT HTR.
UNIT START/TIME
EXPANSION JOINTS
PIPE ANCHORS
TO CIRCULATING PUMP
BOILER SEE INSTALLATION DETAIL
D.H.W. HTR. SEE INSTALLATION DETAIL
UNIT HTR.
UNIT HTR.
UNIT HTR.
PIPE ANCHOR
117
118
116
114
119
115
109
108
107
120
NOTE:
ALL INFRARED HEATERS & TAIL PIPES TO HAVE LOW DEFLECTOR, PARKING GARAGE ONLY.



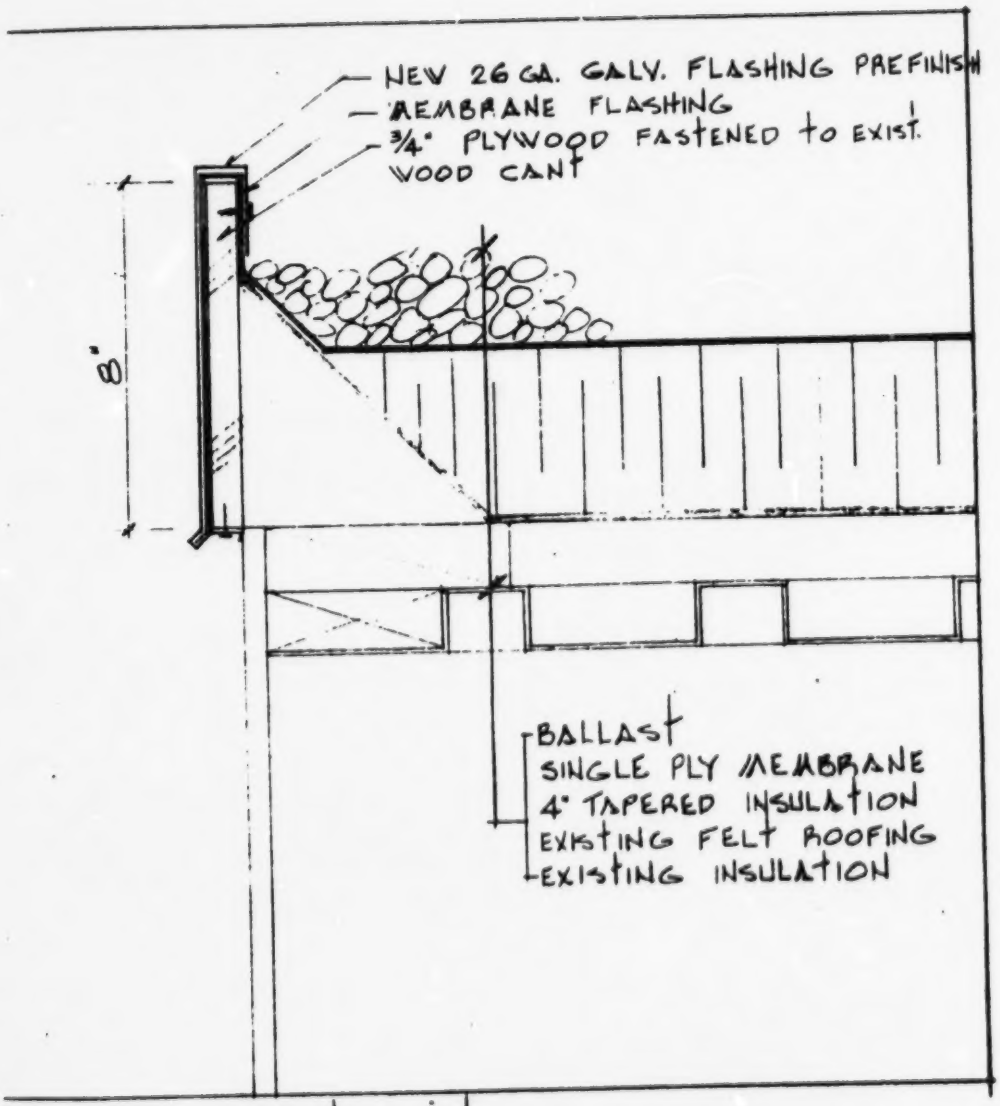
INFRARED HEATING CONTROL SCHEMATIC

W.T.S.

(2 SUCH SYSTEMS)

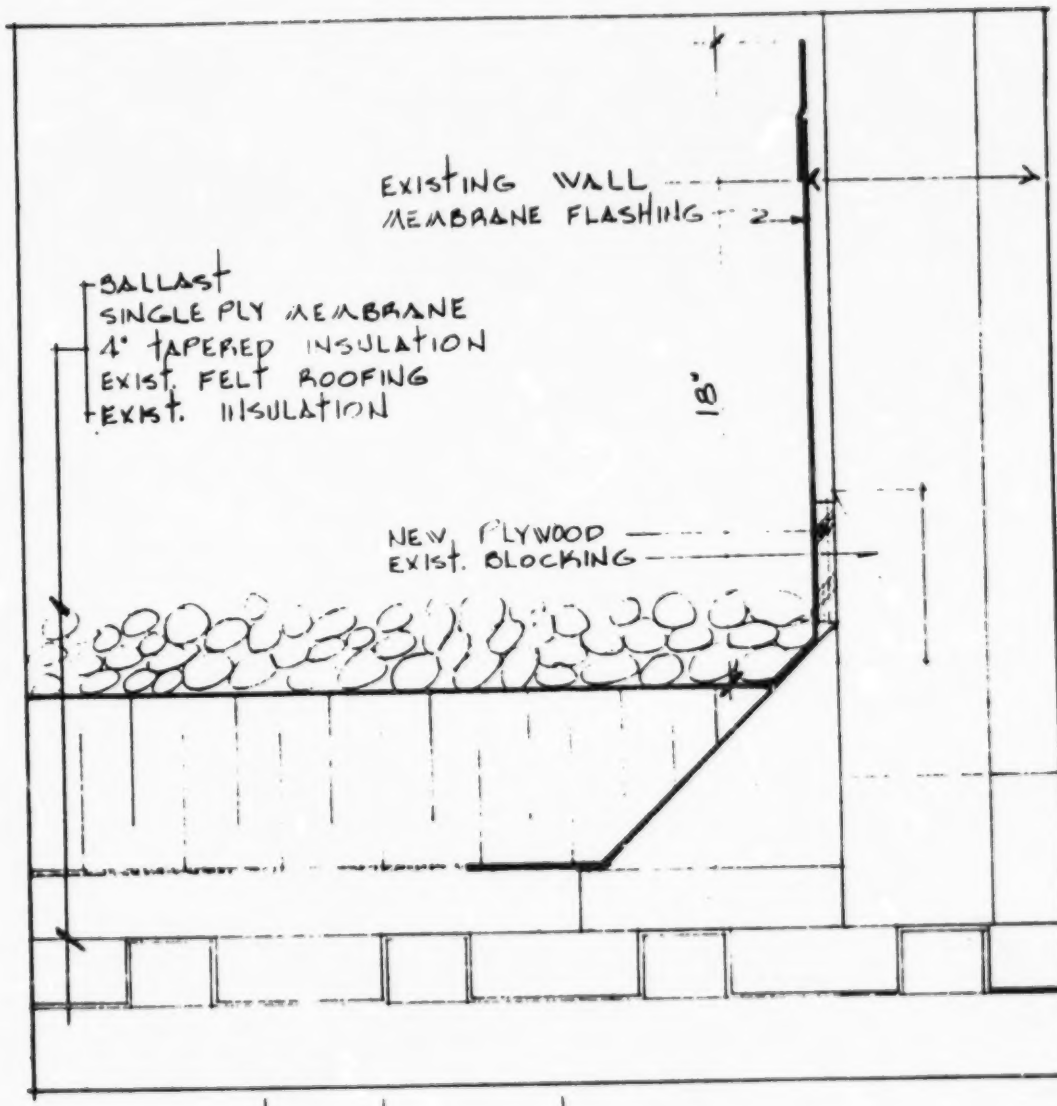


(1) EXISTING CANT DETAIL
SCALE 3" = 1'-0"



NEW CANT DETAIL

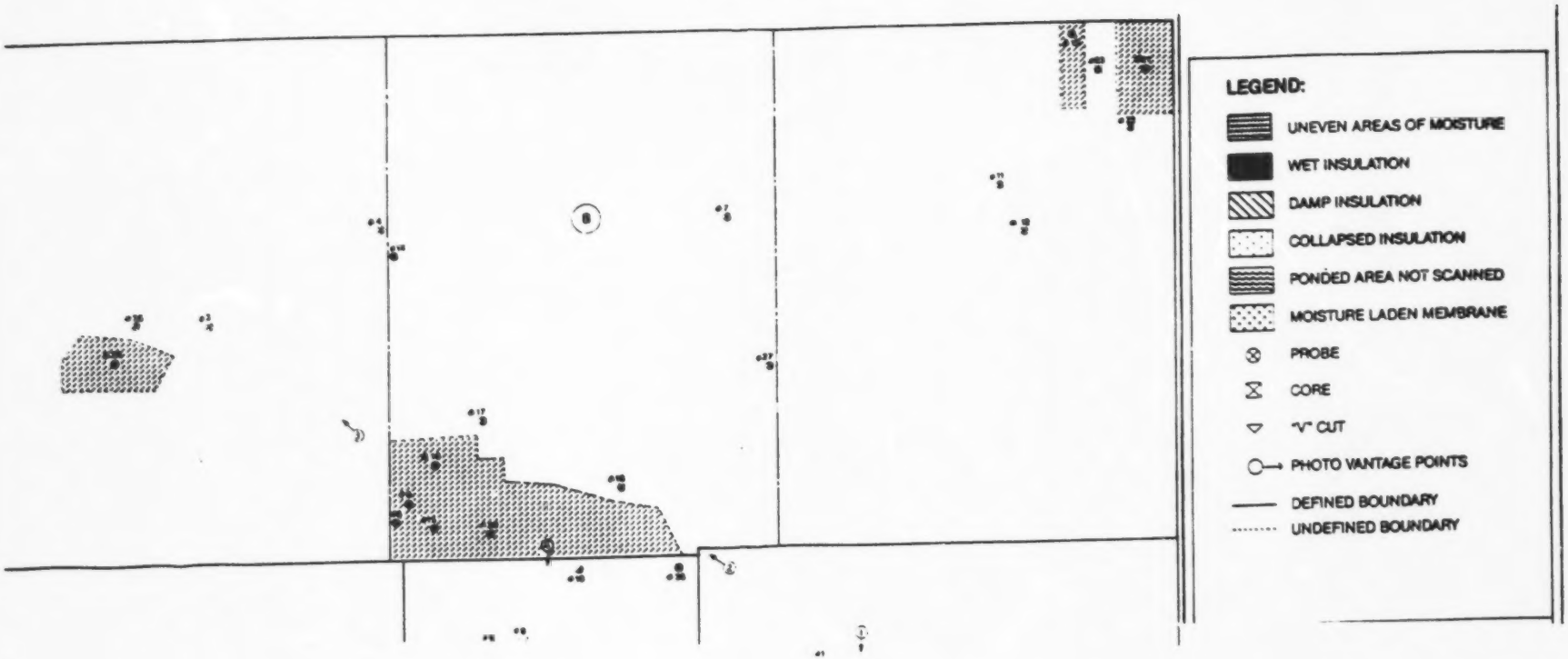
SCALE 3" = 1'-0"



(3) CANT DETAIL AT WALL
SCALE 3" = 1'-0"

APPENDIX "B"

THERMOGRAPHY SCAN


LEGEND:
UNEVEN AREAS OF MOISTURE
WET INSULATION
DAMP INSULATION
COLLAPSED INSULATION
PONDED AREA NOT SCANNED
MOISTURE LADEN MEMBRANE
PROBE
CORE
"V" CUT
PHOTO VANTAGE POINTS
DEFINED BOUNDARY
UNDEFINED BOUNDARY

VERIFICATION DATA

CODIAC TRANSIT - MONCTON, NB

ROOF NO.: A
ROOF TYPE: BUR - A & G
FELTS: 4 Ply
INSULATION TYPE: Fibreglass
THICKNESS: 1 1/2"
VAPOUR RETARDER: Poly
DECK: Metal

CUT NO.	CUT TYPE	FELTS CONDITION	INSULATION CONDITION
8	V-Cut	Dry	Dry
9	Probe	Dry	Dry
10	Probe	Dry	Dry
26	Probe	Dry	Dry

VERIFICATION DATA

CODIAC TRANSIT - MONCTON, NB

ROOF NO.: B
ROOF TYPE: BUR - A & G
FELTS: 4 Ply
INSULATION TYPE: Fibreglass
THICKNESS: 1 1/2"
VAPOUR RETARDER: Poly
DECK: Metal

CUT NO.	CUT TYPE	FELTS CONDITION	INSULATION CONDITION
3	Probe	Dry	Dry
4	Probe	Dry	Dry
5	Probe	Wet	Wet
6	Probe	Wet	Wet
7	Probe	Dry	Dry
11	Probe	Dry	Dry
12	Probe	Dry	Dry
13	Probe	Wet	Wet
14	Probe	Dry	Dry
15	Probe	Wet	Wet
16	Probe	Wet	Wet
17	Probe	Dry	Dry
18	Probe	Dry	Damp
20	Probe	Wet	Wet
21	Probe	Wet	Wet
22	Probe	Wet	Wet
23	Probe	Dry	Dry
24	Probe	Wet	Wet
25	Probe	Dry	Dry
27	Probe	Dry	Dry

VERIFICATION DATA

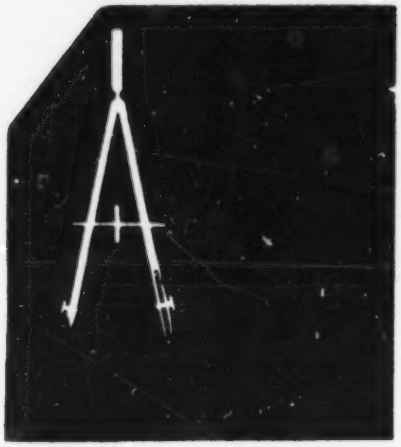
CODIAC TRANSIT - MONCTON, NB

ROOF NO.: C
ROOF TYPE: BUR - A & G
FELTS: 4 Ply
INSULATION TYPE: Fibreglass
THICKNESS: 2"
VAPOUR RETARDER: Poly
DECK: Metal

CUT NO.	CUT TYPE	FELTS CONDITION	INSULATION CONDITION
1	V-Cut	Dry	Dry
2	Probe	Dry	Dry
19	Probe	Dry	Dry

APPENDIX "C"

MAJOR EQUIPMENT DESCRIPTIONS



MonoPly™

Elastomeric membrane for roofing and waterproofing applications.

DESCRIPTION

MonoPly Elastomeric Membrane is a rubber sheet produced in both roll and large blanket form. The large rubber sheets reduce the number of field seams required.

MonoPly offers the following performance advantages:

- Free from splits caused by deck movement
- Excellent ozone, heat, oxidation and chemical resistance
- Excellent moisture resistance
- Can be applied during all seasons, including winter
- Flexible down to extreme low temperatures

Basic Use: For roofing and waterproofing applications:

- New roof construction
- Re-roofing applications
- Retrofit roofing
- Waterproofing of plaza decks, roof terraces, pedestrian concourses or podiums, parking garages
- Suitable for use in loose-laid system with virtually every type of conventional board insulation, and with extruded polystyrene above the membrane (protected membrane assembly)

Limitations: Not designed for use as a finished traffic surface. Do not use material in contact with membrane other than those types recommended by the manufacturer. Contact manufacturer for recommendations where sheet will be directly in contact with acids, oils, solvents, petroleum based materials, etc. Loose laid sheet must be ballasted with a minimum of 49kg/m² (10 lbs./sq.ft.)

Composition and Materials: E.P.D.M. (ethylene propylene diene monomer) in sheet form.

Sheet Sizes: Sheets are factory fabricated:
1.2 mm (47 mil) membrane thickness available in widths of 9.14 m (30 ft), 6.1 m (20 ft.), 4.57 m (15 ft.), and 2.13 m (7 feet). Standard length is 30.48 m (100 ft.).
1.5mm (60 mil) membrane thickness available in widths of 152 mm (6 in), 305 mm (12 in), 457 mm (18 in), 610 mm (24 in), 914 mm (36 in), and lengths of 15.24 m (50 ft.).
1.5 mm (60 mil) membrane thickness available in 2.13 m (7 ft.) width and 30.48 m (100 ft.) length.

Weight: 1.2 mm (47 mil) thickness — 1.36 kg/m² (.28 lbs/sq.ft.)
1.5 mm (60 mil) thickness — 1.8 kg/m² (.35 lbs/sq.ft.)

Colour: Black/Grey

Specific Gravity (ASTM D297): 1.12 ± 0.03

Hardness: (ASTM D2240, Shore A): 60

Permeability, Water Vapour (ASTM E96, process BW): 2.0 perm mils

Standards: Refer to ASTM and C.G.S.B. tests for physical properties tested under Table 1, Technical Data. MonoPly is manufactured to conform to requirements of Canadian General Standards Board (C.G.S.B.) 37-GP-52M, Elastomeric Roofing and Waterproofing Membrane Sheet Applied.

Technical Data — Table I

PERFORMANCE PROPERTY	TEST METHOD[a]	SPECIFICATIONS[a]	TYPICAL PROPERTIES
Tensile Strength	ASTM D412	6 MPa (876 psi) minimum	9.6 MPa (1400 psi)
Elongation	ASTM D412	300%, minimum	300%
Tear Resistance	ASTM D624	26N/mm (148 ppi) minimum	21.9N/mm (125 ppi)
Low Temperature Flexibility	Para 7.2.5	no cracks at – 40°C (– 40°F)	passes
Ozone Resistance	ASTM D3041	no cracks at 100 hours	no cracks
Heat Aging	Para 7.2.8 (10 days at 120°C)	80% retention of strength with 6 MPa (876 psi) and 210% mimimum, passes	10.3 MPa (1500 psi), 225% passes
Water Absorption	Para 7.2.6 (1 week at 70°C)	5% maximum change in mass, less than 10% reduction in strength with a 6 MPa (876 psi) minimum	3% mass change at 10.3 MPa (1500 psi)
Dimensional Stability	Para 7.2.7 (1 week at 70°C)	± 3% maximum change after the water absorption test	1.0%
Tensile Set	ASTM D412 (50% ext)	5%, maximum	3%
Dynamic Impact (Puncturing) Test	Para 7.2.10	2.45 joule minimum using modified Gardner Impact Tester	passes

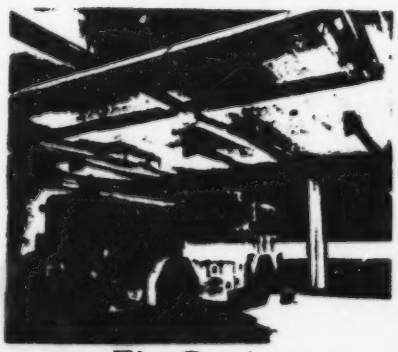
a) Canadian General Standards Board (C.G.S.B.) 37-GP-52M.

FUEL SAVINGS START AT THE TOP WITH A

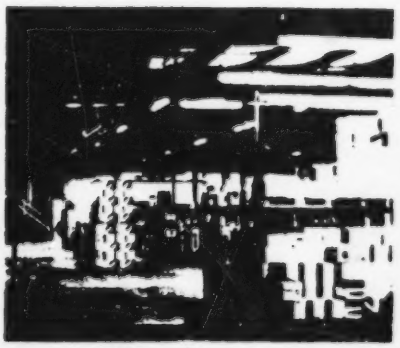
CO-RAY-VAC®

RADIANT HEATING SYSTEM

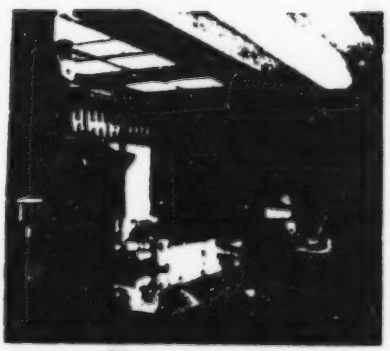
The only infrared tube system with burners in series producing more uniform heat.



Fire Station



Warehouse



Restaurant

Slash fuel bills up to 50% and more by reducing fuel consumption

CO-RAY-VAC uses less fuel than other heating systems. Because less fuel is used, heating bills are lower. These fuel savings are due to the sum of four major factors:

■ High Combustion Efficiency

The patented CO-RAY-VAC system is the only gas-fired, vacuum-controlled tube type radiant heating system manufactured in Canada that has burners firing in series to produce more uniform heat. With exhaust temperatures of 150° to 200°F (66° to 93°C) it achieves a combustion efficiency in the range of 90%. Unit heaters and central heating systems with exhaust temperatures of 500°-600°F (260°-315°C) have combustion efficiencies of 60-75%. CO-RAY-VAC's high combustion efficiency turns almost every BTU generated into usable heat.

■ Less Heat Stratification

CO-RAY-VAC beams its heat downward to people, floors and objects. The floors and objects become reservoirs of heat so when open doors are closed, comfort conditions are quickly regained. With warm air systems, air is heated and rises causing cold conditions at floor level and stratification of warm air at the roof. CO-RAY-VAC drastically reduces heat stratification.

■ Comfort at Lower Temperatures

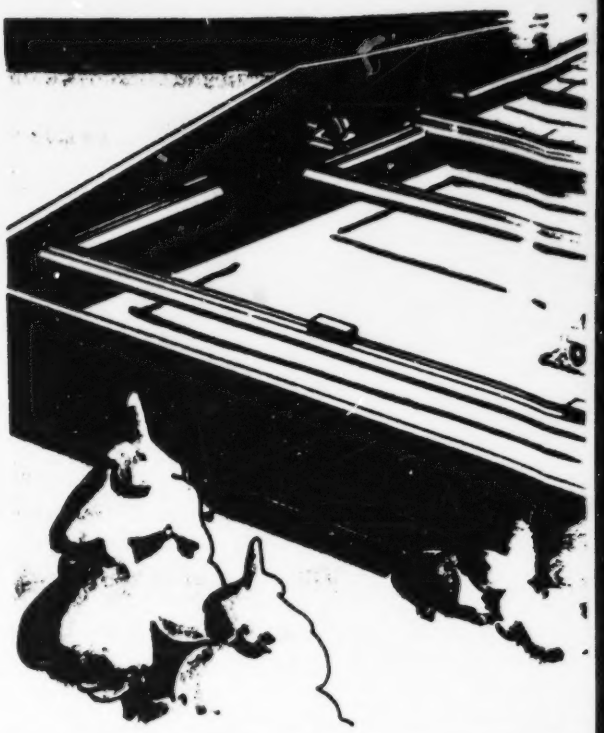
CO-RAY-VAC users report that inside air temperatures have been kept 5-10°F (2 to 5°C) lower while maintaining the same comfort level.

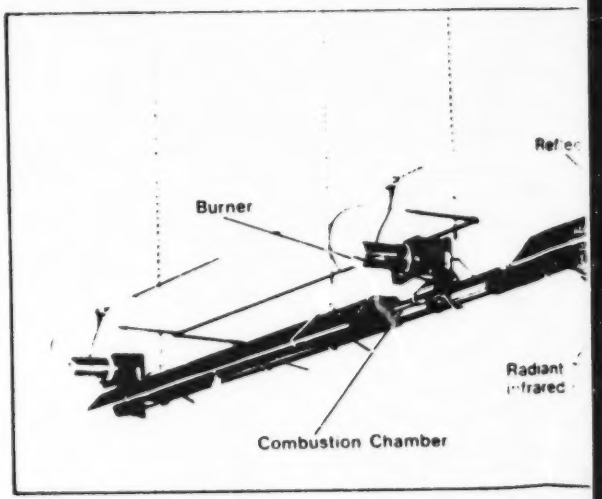
■ Reduced Building Heat Loss

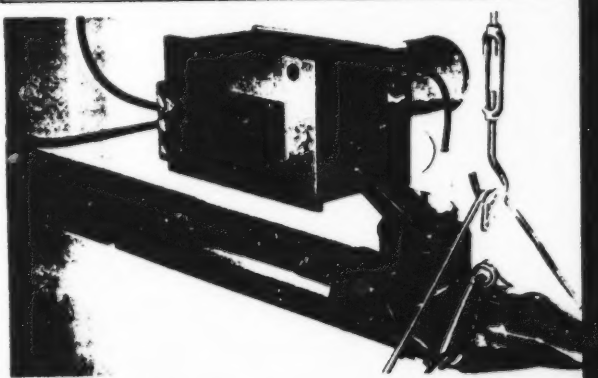
CO-RAY-VAC's vacuum pump closes the system when it is not firing, so there is no heat lost out the exhaust tubes. Standard automatic electric spark ignition means there are no standing pilots to waste fuel.

How a Typical CO-RAY-VAC Heating Installation Works

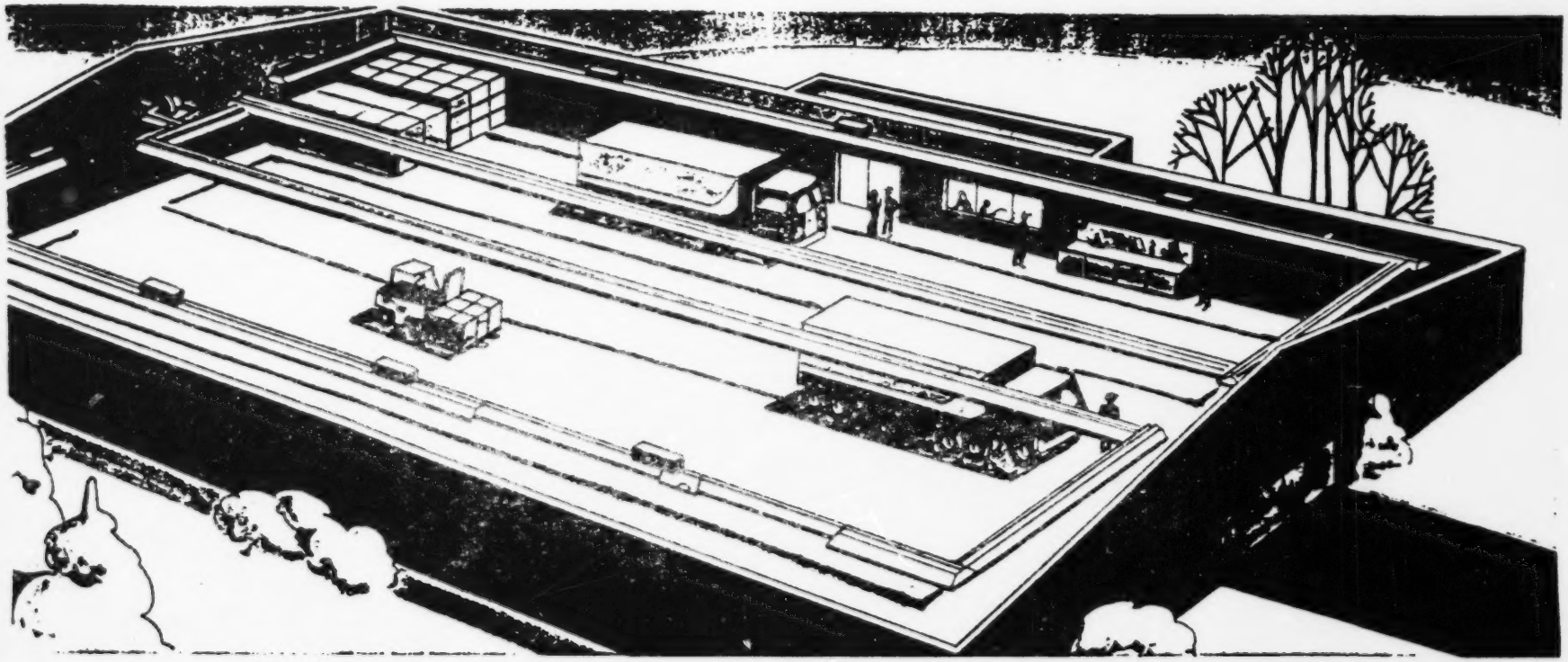
The system consists of a number of burners connected by tubes which radiate heat. The entire system is suspended from the ceiling. Metal reflectors over the tubes direct heat downward, warming people and objects below. There is no blowing of air to create warm and cold spots or to stir up dust and dirt. At the end of the system a powerful exhauster expels the by-products of combustion outdoors.

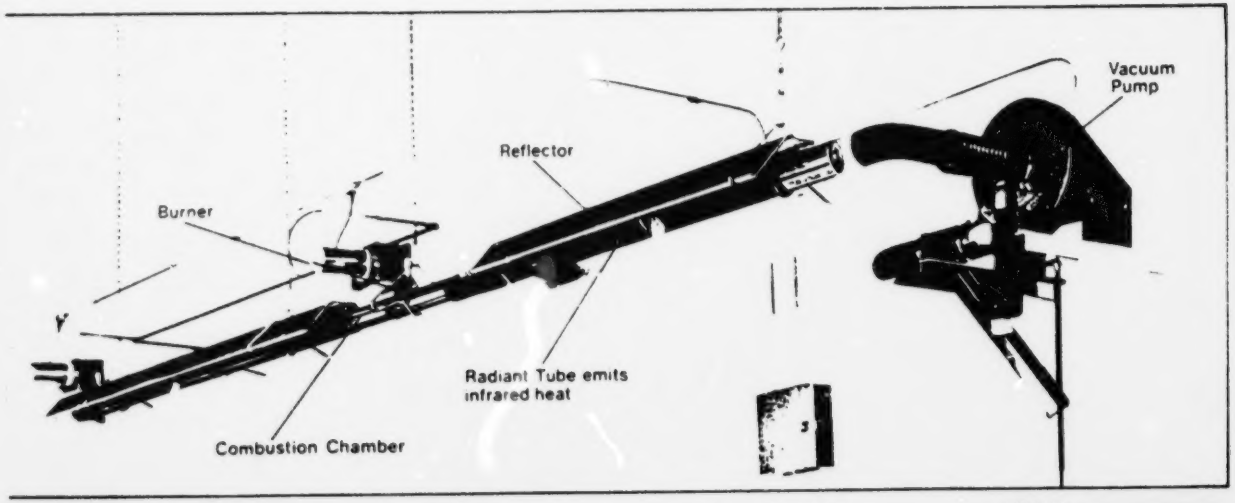


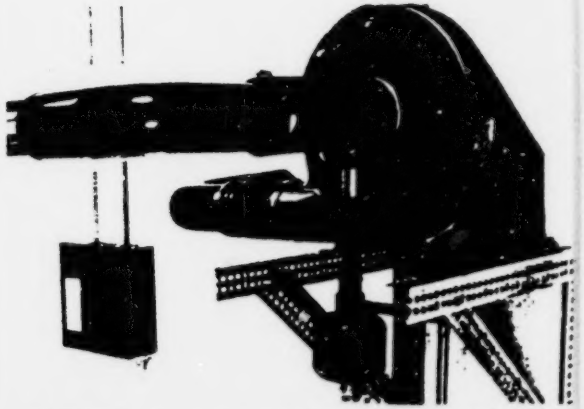




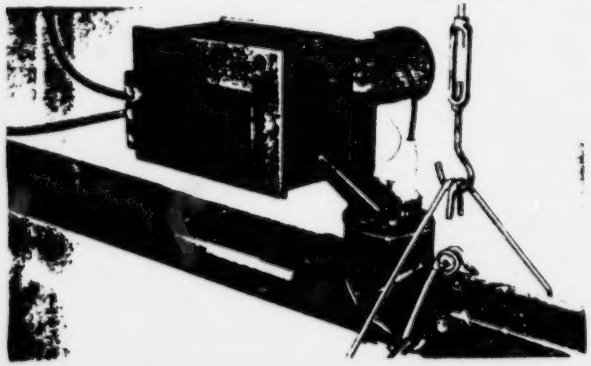
Burners: CO-RAY-VAC unique burners constantly regulate air-to-gas mixture to achieve the very best ratio for clean, effi combustion. Each burner is in effect a miniature furnace occup a space about 1 ft. (30 cm) high by 1½ ft. (46 cm) long. CO-RAY-V is the only CGA certified system that has burners firing one afte other down the same length of tube. This unique design provides h levels of comfort and heat uniformity.







Exhauster: A heavy cast iron vacuum pump located at the e of the system draws the heat through the system and co pletely exhausts all the products of combustion to the outdo at temperatures usually below 200°F (93°C).



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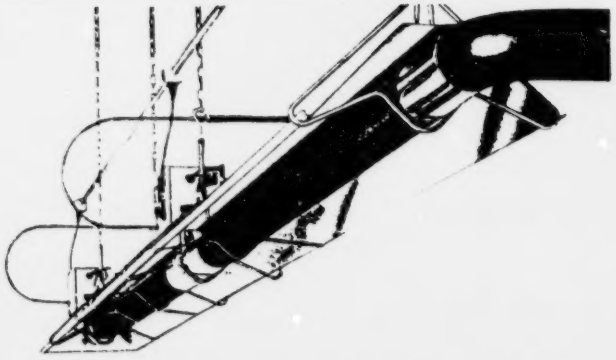
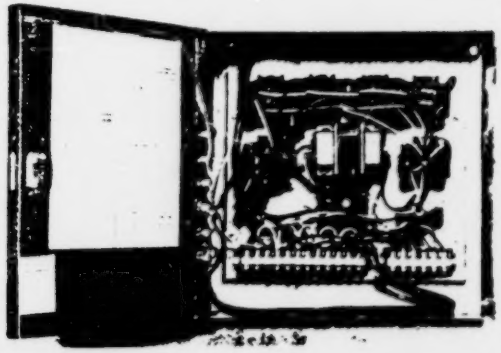


Radiant Tubes and Reflectors: The burners are located about 20' (6 m) apart and are connected by radiant tubes. The heat created by the burners is drawn through the tubes, which radiate warmth. Aluminum reflectors reflect heat towards the floor where it is most needed.



Pre-Wired Control Panel: CO-RAY-VAC heating systems controlled by a pre-wired control panel. These panels assembled and tested at the factory to reduce installa labor. The panel contains 4 zone relays which allow the syst to be divided into separate heating areas each with its thermostat